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KIMBOROUGH HOSPITAL ENERGY AUDIT

NUS Corporation
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Rockville, Maryland 20850

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September 1981

Final Report

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Prepared for:

U. S. Army Facilities Engineering Support Agency
Technology Support Division
Fort Belvoir, Virginia 22060

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KIMBOROUGH HOSPITAL ENERGY AUDIT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The results of an energy audit on Kimborough Hospital, Fort Meade, Maryland, are detailed herein. The report investigates various systems which consume energy in order to identify energy conservation opportunities. These selected systems include HVAC equipment, temperature and humidity controls, heat recovery equipment, building insulation, ventilation rate reduction, lighting systems and domestic hot water. The study analyzes energy conservation opportunities to determine which are cost effective and produce adequate energy savings.

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KIMBOROUGH HOSPITAL ENERGY AUDIT

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1.0 INTRODUCTION

The Department of the Army, Baltimore District, Corps of Engineers, under work order contract DACA 31-80-0019 Task Order 00006 dated April 21, 1980, assigned NUS Corporation to perform an energy audit of the Kimborough Army Hospital at Fort Meade, Maryland. The philosophy of the project was to carry out the energy audit in three separate parts or levels of effort. The first level of effort was to identify energy saving opportunities by means of site inspection and engineering judgement. The second level involved metering of the hospital's energy consumption and making appropriate hand calculations to confirm the accuracy of the Level 1 recommendations and identify additional energy saving opportunities. The third level of effort utilized computer modeling as a tool to investigate further energy savings possibilities.

2.0 SUMMARY OF FINDINGS

The Kimborough Army Hospital is in excellent condition, has already adopted energy conservation programs, and maintains an outstanding planned maintenance program to keep equipment in top condition. Nevertheless, there are several projects which, if incorporated, can save the hospital approximately $57,000 (1980 dollars) per year with a simple investment payback of less than 1.6 years. This saving represents approximately a 12% reduction in energy cost (1980 dollars).

2.1 General Condition of the Hospital

The Kimborough Army Hospital was built in 1958. A new addition was added several years later. The hospital consists of one three story, block and brick veneer structure with three wings totaling approximately 138,660 square feet and providing sufficient space for 300 beds; and a new single level clinic of approximately 56, 217 square feet. The entire hospital totals approximately 194,880 square feet.

The building characteristics that place this hospital into an energy efficient category are as follows:

- All windows are presently double glazed
- All entrances (except for rear emergency exits) are double door entrance foyers
- Compared to the building size, the heating, ventilating and air conditioning units are operated at relatively low outside air inlet flow rates
- All lighting (except for the machine spaces) is done with fluorescent fixtures
- All mechanical and electrical equipment is well maintained, and controls are calibrated at frequent intervals

2.2 Potential Energy Saving Projects

The energy audit exposed six potential energy savings projects; four of these require capital energy saving investment with the other two requiring only maintenance. In addition, two alternative projects are listed for information. A summary of these projects is presented in Table 1. All costs presented, both in this table and other sections of the report are in 1980 dollars.

TABLE 1

SUMMARY OF ENERGY SAVINGS PROJECTS

Item	Project	Annual Energy Savings Potential (Million BTUs)	Annual Cost Savings Potential (1960 Dollars)	Estimated Installed Cost (1980 Dollars)	Simple Payback Time (Years)	E/C Ratio (Million BTU/ $1000 Investment)
1	New Clinic Fan Cycling Control	5,755	$32,780	$12,000	0.4	480
2	Induced Air Makeup System for Kitchen Exhaust Hoods	936	$13,570	$10,000	0.6	117
3	Waste Heat Recovery Loop Between Exhaust and Inlet Ventilation Ducts	240	$ 6,068	$10,000	1.6	25
4	Additional Insulation to the Roof of the Old Hospital	373	$ 4,150	$19,000	4.6	19.6
5	Fix Leaking Condensate Return	9.6 960 Gallons of Water	$ 135	No cost other than maintenance and repair parts	1.0	50 (approx.)
6	Repair of Steam Leakage from Domestic Hot Water System	43.8 5290 Gallons of Water	$ 497	No cost other than maintenance and repair parts	1.0	50 (approx.)
7	Additional Insulation to the Roof of the New Clinic without Fan Cycling	579	$ 6,078	$28,000	4.6	20.7
8	Additional Insulation to the Roof of the New Clinic with Fan Cycling	211	$ 2,529	$16,800	6.6	12.5

3.0 DISCUSSION OF PROJECT DEVELOPMENT VS. LEVEL OF EFFORT

The costs and levels of effort expended to identify energy savings projects are summarized in Table 2.

3.1 Level 1 - Hospital Survey and Drawing Review

Because the Kimborough Hospital is in excellent condition and most low cost energy saving concepts have already been incorporated, no new, non-capital intensive projects were yielded by the Level 1 effort. Only maintenance projects numbers 5 and 6 were identified. Nevertheless, the Level 1 survey information was essential for the more complex projects identified in Levels 2 and 3. The Level 1 effort consumed approximately 25 percent of the total project budget.

3.2 Level 2 - Metering Of Energy Consumption And Evaluation By Hand Calculations

Two major energy savings projects were identified during this phase of the work effort. Project 1, a microprocessor control system to cycle ventilation fans in the new addition was identified as a result of metering the electric consumption of the new addition over a period of one month. It was noted that the electric power consumption during the non-working hours (nights and weekends) was a steady 50 percent of the maximum power consumed during weekdays. Based upon a review of electrical drawings of the new addition, it was concluded that most of the non-working hour power consumption was due to the ventilation fans. Consequently a fan cycling project was identified to reduce power consumption during these times. The overall evaluation of this project to determine its total energy savings potential had to wait, however, until Level 3 was performed.

The second energy saving project identified in Level 2 was the kitchen induced air makeup system, project 2. A major kitchen exhaust load consuming large quantities of winter heating energy was identified. Consequently, the induced air makeup system for the kitchen exhaust loads was developed to reduce the amount of heated air exhausted to the outside. Hand calculations were made to estimate the energy and cost savings, therefore, project 2 was fully developed as a result of the Level 2 effort. Level 2 effort consumed approximately 25 percent of the project budget.

3.3 Level 3 - Computer Modeling of the Hospital and Subsequent Evaluation of Potential Modification

The DOE - II computer code was utilized to evaluate the more complex energy saving projects. This code was employed to predict the heating and cooling loads as they would be affected by changes to ventilation flow rates, insulation, and heating and ventilation system changes. The computer analysis was used to predict the energy savings potential for project 1 (fan cycling in the new addition), project 3 (waste heat recovery loop between exhaust and inlet ventilation ducts), and project 4 (additional insulation to the top floor ceiling in the old section of the hospital). In addition, the computer was employed to perform sensitivity analyses for the addition of insulation to the new addition, both with and without fan cycling (projects 7 and 8). The remaining 50 percent of the budget was expended in the completion of the Level 3 effort.

TABLE 2

PROJECT DEVELOPMENT VERSUS LEVEL OF EFFORT

LEVEL OF EFFORT	DESCRIPTION OF TYPICAL ACTIVITIES	ENERGY SAVING PROJECT FOR WHICH THE ACTIVITY WAS REQUIRED								APPROXIMATE PERCENTAGE OF BUDGET EXPENDED ON LEVEL OF EFFORT
		1	2	3	4	5	6	7	8	
1	Survey Hospital; Review Drawings; Engineering Judgments	X	X	X	X	X	X	X	X	25
2	Install Energy Recorders; Review Data; Perform Hand Calculations;	X	X						X	25
3	Computer Modeling of Hospital; Evaluate Changes to Systems; Evaluate Computer Outputs	X		X	X			X	X	50
	Approximate Percentage of Budget Expended on Project	36	10	16	12	2	2	12	10	100

4.0 ENERGY CONSUMPTION BREAKDOWN

A breakdown of the energy consumption of the Kimborough Army Hospital is listed as follows:

- o Heating
- o Humidification
- o Cooling
- o Fans
- o Lighting
- o Kitchen
- o Miscellaneous (i.e., office equipment, air compressors, x-ray and other medical equipment)
- o Domestic hot water

4.1 Heating Loads and Cost

The annual heating and humidification requirements for the hospital are estimated to be 23.5 billion BTUs per year with a maximum January heating load of 5.0 billion BTUs.

The heating loads are supplied by a central steam boiler house containing three boilers fired by number 2 or number 6 fuel oil. This boiler house provides the steam needs for the hospital, a hospital staff barracks building, a medical laboratory, and a warehouse. The hospital consumes approximately 75% of the total steam generated by the boiler house.

The estimated cost for heating the hospital is based on the hospital heating loads, shown in Figure 1, a boiler efficiency of 83%, and a fuel oil cost of approximately \$1.30/gallon (for number 2 fuel oil at 140,000 BTUs/gallon). The estimated 1980 heating cost then computes to \$263,000 per year.

4.2 Cooling Loads and Cost

The expected cooling loads for the hospital are also plotted in Figure 1. The yearly cooling requirements are estimated to be 7.6 billion BTUs per cooling season. The maximum hourly cooling load is expected to occur in June at approximately 6.6 million BTU/hour. This cooling load draws additional electrical energy of approximately 557,000 KWhr during the cooling season. In addition, the maximum cooling load creates an additional electrical demand of approximately 483.6 KW.

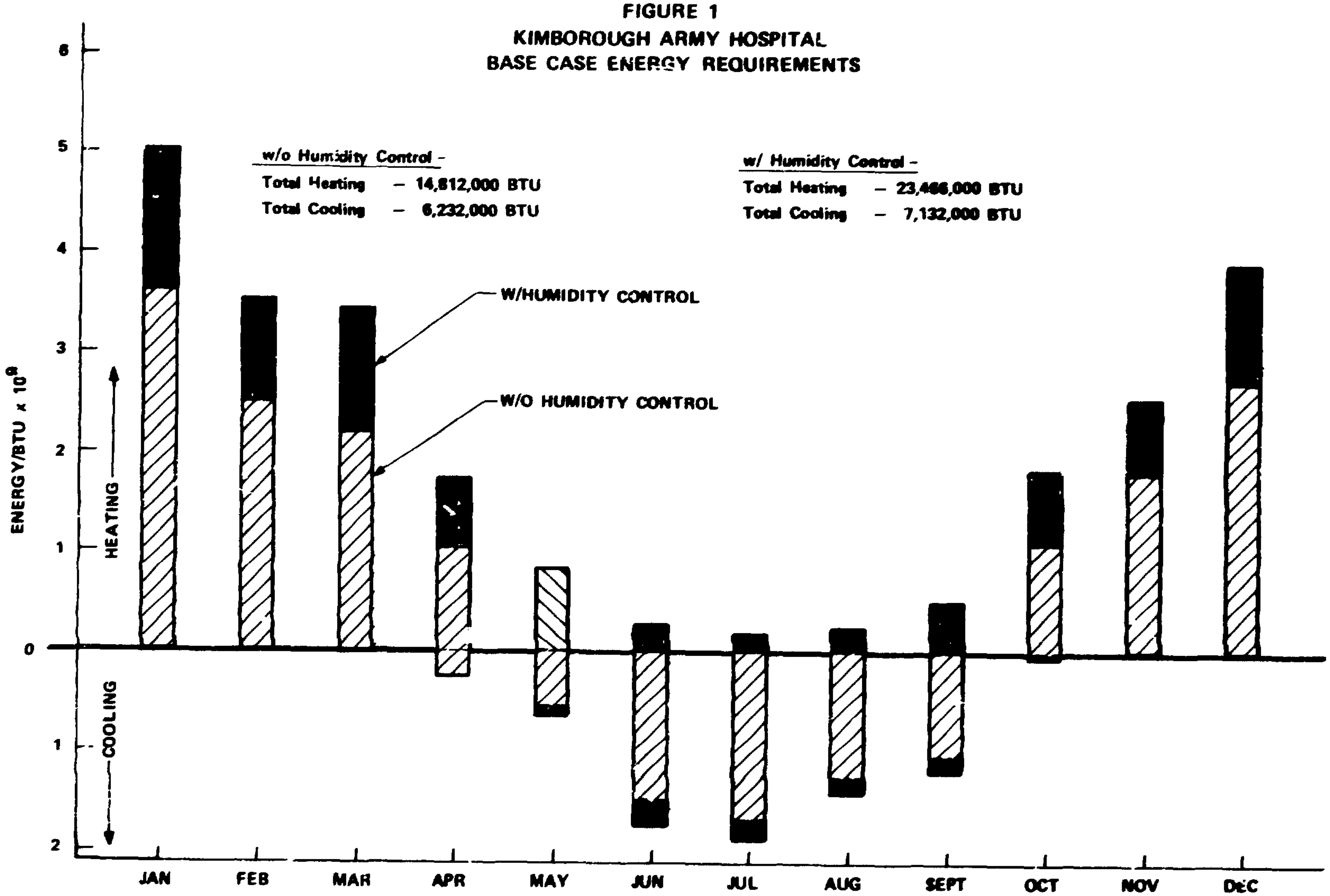
The estimated cost for providing the cooling is based on the season cooling electrical energy requirement and an estimated cost of 0.04 \$/KWhr (based on an average demand charge of 0.0089 \$/KWhr; fuel charge of 0.02 \$/KWhr; and an average generation charge of 0.011 \$/KWhr). Therefore, the estimated cost for air conditioning is \$22,350 per season.

4.3 Electricity Energy Demands

4.3.1 Winter Electric Loads

During the winter months, the Kimborough Army Hospital is presently consuming 60,130 KWhr per week of electric energy with a peak load of approximately 500 KW.

FIGURE 1
KIMBOROUGH ARMY HOSPITAL
BASE CASE ENERGY REQUIREMENTS



The typical weekly profile is shown in Figure 2 for January weather. This electric load is essentially independent of cooling and heating needs. It consists of the following items:

- Ventilation and air circulation fans - approximately 164 KW - for an estimated 1,428,000 KWhr/yr
- Lights - approximately 224 KW - for an estimated 892,000 KWhr per year
- Other hospital equipment - approximately 90 KW - for an estimated 805,920 KWhr per year

These loads together total approximately 3,126,600 KWhr/year.

.3.2 Summer Electric Loads

During the summer months, cooling adds an additional maximum load of approximately 484 KW and consume an estimated 557,000 KWhr during the cooling season.

Annual Electric Loads

The expected annual electrical energy consumption is plotted in Figure 3. The total annual electricity consumption (summer plus winter) is estimated to be approximately 3,683,500 KWhr. The cost for this electric energy is approximately $147,300 per year.

Actual total charges for electricity are, of course, based upon a combination of charges for usage (KWH) and demand (KWD). Since Fort Meade is metered as a unit, the applicable demand charge is determined by the peak loading for the entire base. The effect of peak reduction at Kimborough Hospital upon the peak of the base as a whole is indeterminate. Therefore, electricity charges used in this report have been determined utilizing average demand charges for the base as a whole.

.4 Total Energy Cost

Table 3 presents the total energy consumption and cost. The total annual energy cost for heating, cooling, humidification, kitchens, and other electric usage is approximately $427,420 per year.

.0 ENERGY SAVING MODIFICATIONS WITH GOOD ECONOMIC INCENTIVE

Based on the survey taken of the Kimborough Army Hospital, the following modifications or corrections have been identified that will save energy and lower operating cost with a high degree of economic merits. These modifications/corrections are as follows:

- Install a microprocessor controller to cycle the ventilation fans in the new clinic section based on time of day and day of week.
- Install an induced air makeup system to the exhaust ventilation hoods in the kitchen.

FIGURE 2
TYPICAL ELECTRICAL LOAD FOR A WEEK IN JANUARY

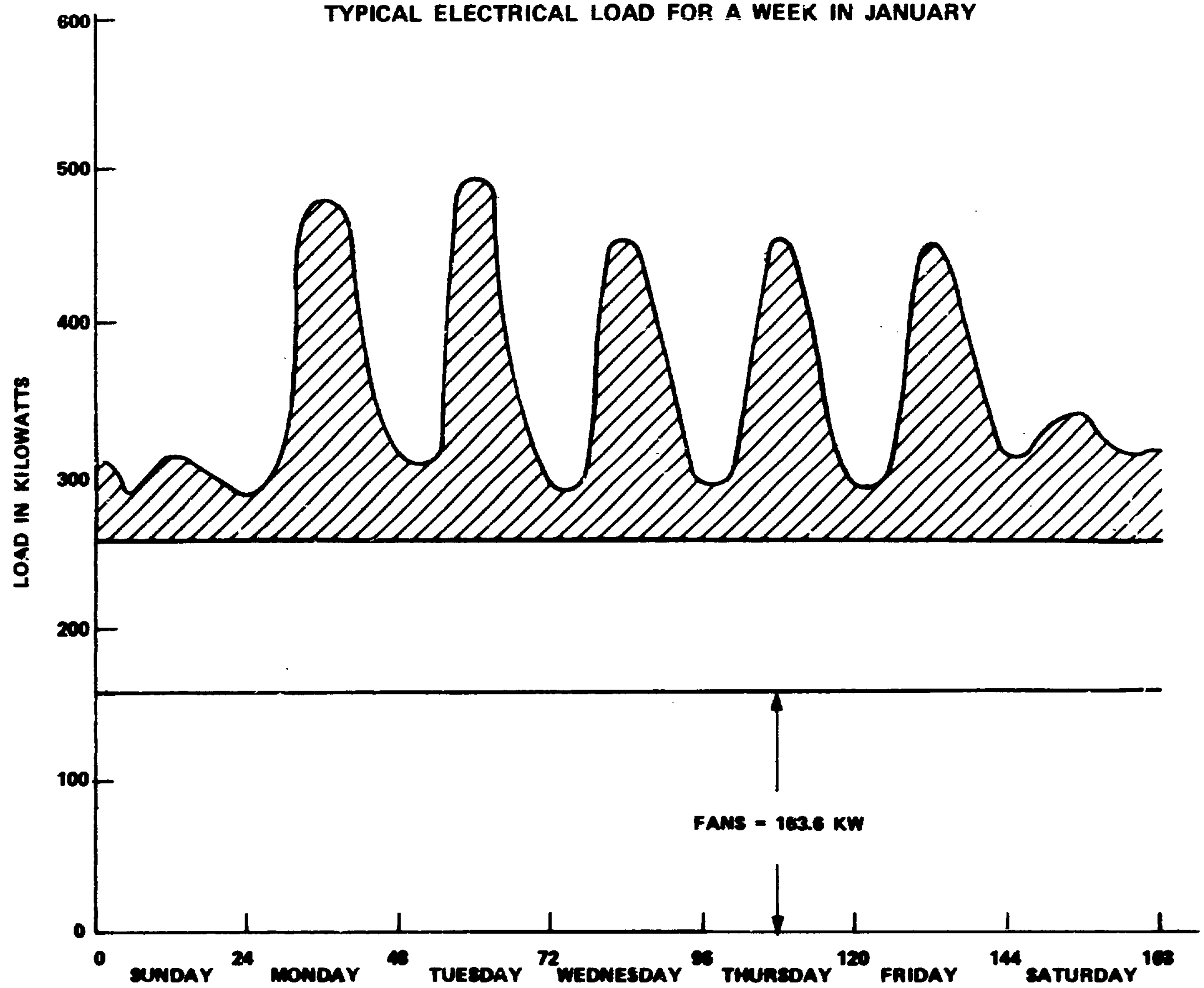
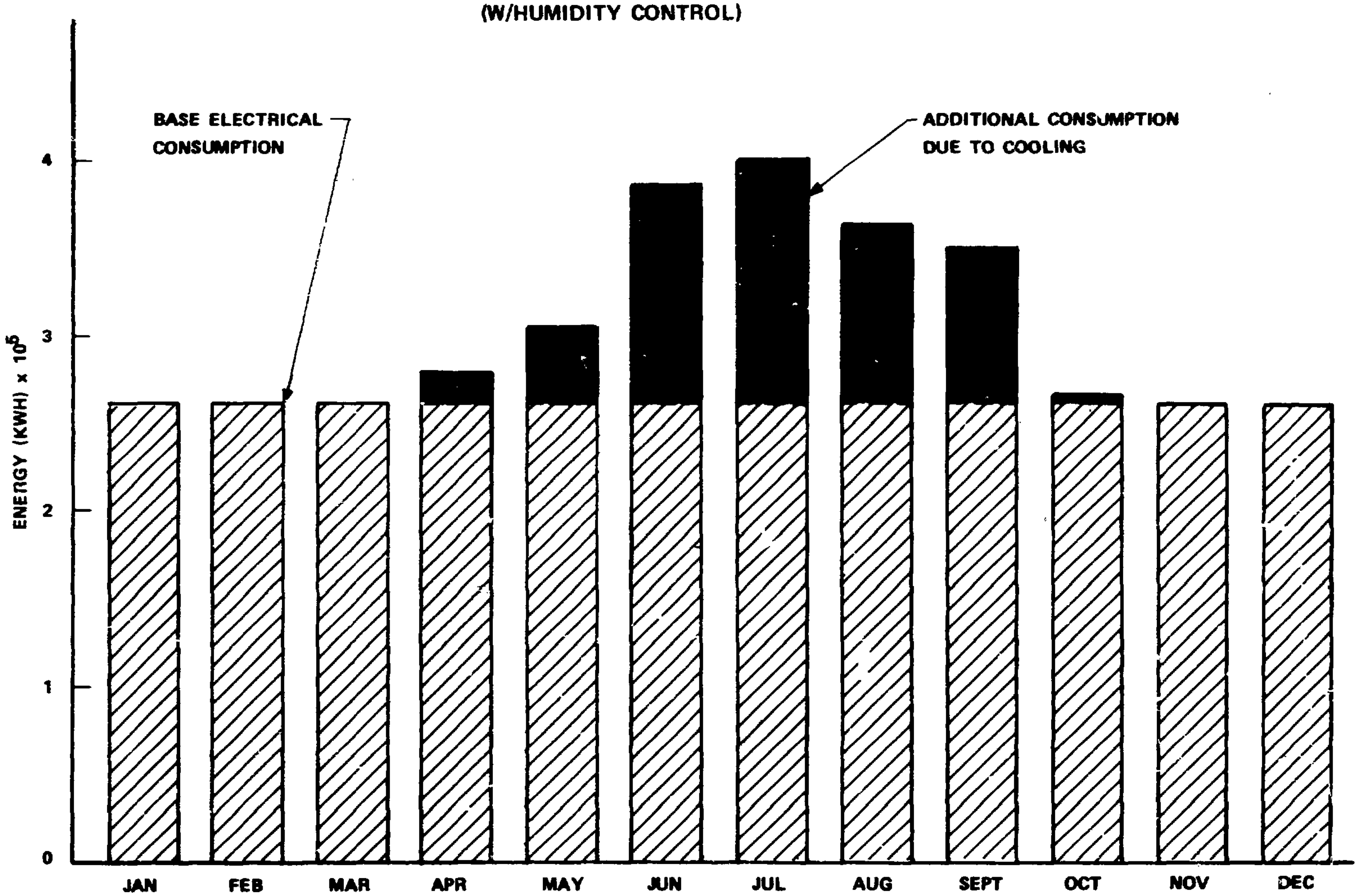


FIGURE 3
KIMBOROUGH ARMY HOSPITAL
ELECTRICAL CONSUMPTION
(W/HUMIDITY CONTROL)



(TOTAL YEARLY ELECTRICAL CONSUMPTION = 3,640,000 KWH)

TABLE 3

ENERGY CONSUMPTION AND COSTS FOR KIMBOROUGH ARMY HOSPITAL

Item	Annual Energy Use	Annual Cost	%Based on Costs
Heating	14.8x10 BTUs	$165,760	38.8
Humidification	8.6x10 BTUs	$99,680	23.3
Fans	1,428,640 KWhrs	$57,150	13.4
Lights	891,990 KWhrs	$35,680	8.3
Cooling	55,7000 KWhrs	$22,350	5.2
Kitchen	1.2x10 BTUs	$13,440	3.1
Domestic Hot Water	0.1x10 BTUs	$1,120	0.3
Miscellaneous	805,920 KWhrs	$32,240	7.5
Total:		$427,420	100

- Install a heat recovery loop between the ventilation exhaust and inlet air ducts

- Install two inches of insulation above of the drop ceiling beneath the roof of the original hospital section.

- Repair the leaking condensate return sump tank and pumps serving the new clinic addition.

- Repair the leaking steam traps serving the domestic hot water system.

The detailed explanation for these modifications regarding energy and cost savings is presented in the following paragraphs.

5.1 Fan Cycling For New Clinic Addition.

The present operation of the new addition allows the ventilation fans to continue operation during periods when the building is unoccupied. These unoccupied periods are primarily Saturdays, Sundays, and weekdays between 6:00 p.m. and 8:00 a.m. Figure 4 presents typical electrical load during January for the clinic section. As shown in the figure, there is a steady minimum demand of approximately 90 KW that occurs during the unoccupied hours of which approximately 70 to 80 KW are supply, return and exhaust fans. By establishing a new schedule which allows the fan operation to be curtailed and temperatures to be reduced, significant heating, cooling, and electric energy can be saved. Table 4 presents such a suggested schedule.

Figure 5 shows the estimated difference in energy consumption for this modification. These savings are estimated to be as follows:

Heating	1570 million BTUs Saved
Cooling (Electrical Load)	37,000 KWhr Saved
Fan (Electrical Load)	343,210 KWhr Saved
Fuel saved at Electric Generating Station (Baltimore Gas & Light)	4185 million BTUs Saved

The cost savings to the hospital associated with this energy saving is estimated to be $17,570 for heating oil and $15,210 for electricity for a total savings of $32,780 per year.

The control equipment necessary to incorporate a fan cycling schedule would be a small microprocessor programmed with the control schedule logic. These microprocessors are commercially available. They have an internal clock that keeps track of time of day and days per week. Temperature inputs to these controllers are obtained via thermostats placed in the rooms served by the ventilation system. Approximately four inputs would probably be required for Kimborough Hospital. The outputs from the controller are relay switches that turn equipment "on" or "off" in accordance with the programmed logic.

The installed cost for a microprocessor and associated equipment to cycle the ventilation fans is estimated to be approximately $12,000. (This is based on comparative installed cost of micrprocessor building control system.)

FIGURE 4

KIMBOROUGH ARMY HOSPITAL – NEW ADDITION

TYPICAL ELECTRICAL LOAD FOR A WEEK IN JANUARY

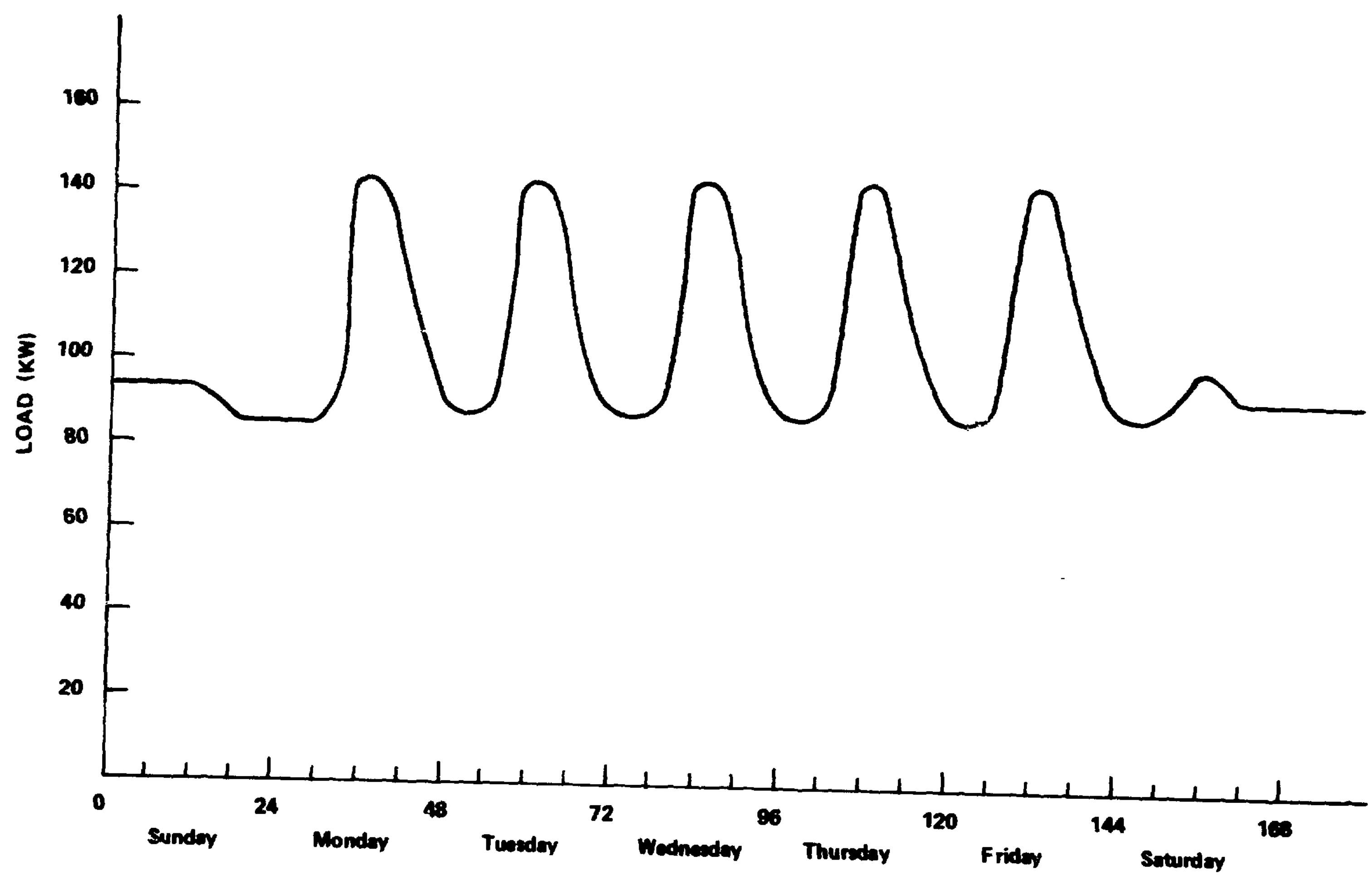
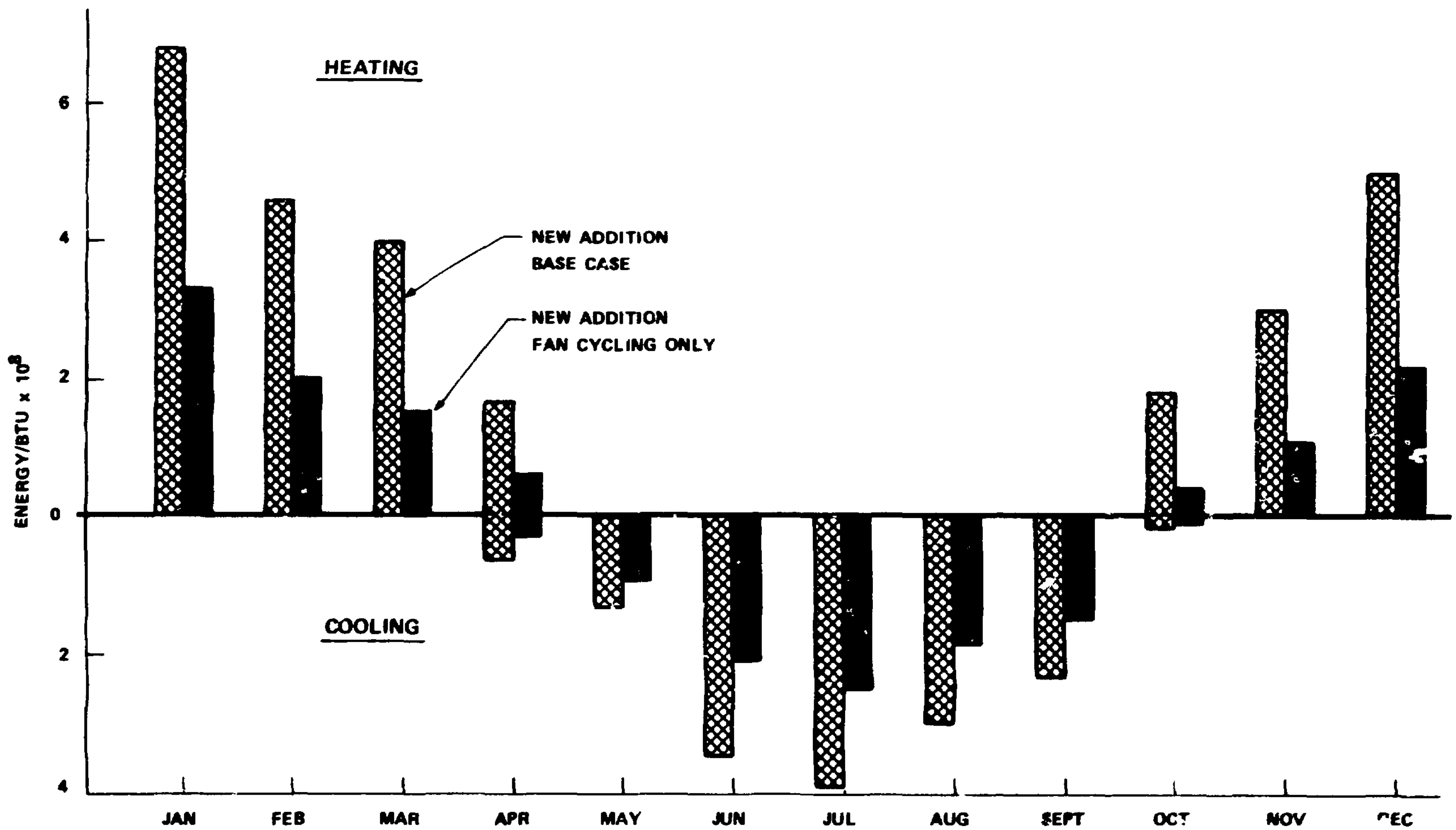


TABLE 4

PROPOSED FAN CYCLING SCHEDULE FOR THE NEW ADDITION

Time	*Fan Operation*	*Thermostat Set Points*
Weekdays		
8 a.m. to 6 p.m.	All run	75°F
6 p.m. to 8 a.m.	All off except to maintain clinic above 58°F during winter months	58°F
Saturday & Sunday	All off except to maintain clinic above 58°F during winter months	58°F

FIGURE 5


HEATING
COOLING
NEW ADDITION
BASE CASE
NEW ADDITION
FAN CYCLING ONLY
ENERGY/BTU x 10^8
6
4
2
0
2
4
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital **FY** 1981

Project: Install microprocessor to cycle air handling fans on new addition

Economic Life 10 **Yrs. Date Prepared** 3/7/81 **Prepared by** R. W. Fell

COSTS

1.	**Non-Recurring Initial Capital Costs:**	
	a. CWE	$ 12,000
	b. Design	$ 0
	c.	$ 0
	d. Total	$ 12,000

BENEFITS

2.	**Recurring Benefit/Cost Differential Other than Energy:**	
	a. Annual Labor Decrease (+)/Increase (-)	$
	b. Annual Material Decrease (+)/Increase (-)	$
	c. Other Annual Decrease (+)/Increase (-)	$
	d. Total Costs	$
	e. 10% Discount Factor	$
	f. Discounted Recurring Cost (d x e)	$
3.	**Recurring Energy Benefit/Costs:**	
	a. Type of Fuel: Oil	
	(1) Annual Energy Decrease (+)/Increase (-)	1,570 MBTU
	(2) Cost per MBTU	$ 11.19
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 17,570
	(4) Differential Escalation Rate (8 %) Factor	9.136
	(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 160,520
	b. Type of Fuel: Electricity	
	(1) Annual Energy Decrease (+)/Increase (-)	380,210 KWH*
	(2) Cost per KWH	$ 0.04
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 15,210
	(4) Differential Escalation Rate (7 %) Factor	8.737
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ 132,890
	c. Type of Fuel:	
	(1) Annual Energy Decrease (+)/Increase (-)	
	(2) Cost per MBTU	$
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$
	(4) Differential Escalation Rate (%) Factor	
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
	d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 293,410
4.	**Total Benefits (Sum 2f+3d)**	$ 293,410
5.	**Discounted Benefit/Cost Ratio (Line 4/Line 1d)**	24.4
6.	**Total Annual Energy Savings (3a(1)+3b(1)+3c(1))**	5,755 MBTU
7.	**E/C Ratio (Line 6 ÷ Line 1a/1000)**	480
8.	**Annual $ Savings (2d+3a(3)+3b(3)+3c(3))**	$ 32,780
9.	**Pay-Back Period ((Line 1a - Salvage)÷Line 8)**	0.4 Years

*4,185 MBTU at generating station

Based on the cost savings due to reduced energy consumption and the estimated installed capital cost, the simple payback period for this modification is less than one half a year; the present worth of the savings is approximately $293,410 (for a ten year depreciation, 10% return on present worth, and 8% fuel escalation over inflation), and the energy saved per $1000 investment (E/C ratio) is 480.

5.2 Install Induced Air Makeup System for Kitchen Exhaust Hoods

The amount of kitchen conditioned air exhausted to the outside could be significantly reduced by circulating unconditioned outside air directly underneath the exhaust hoods over the stoves as is commonly done on new systems. A constant volume fan is used so that air flow velocities within the hood remain unchanged and grease separation efficiency of the hood is maintained. However, because unconditioned outside air is directed underneath the hood, the quantity of room conditioned air exhausted by the hood is reduced. This reduction in conditioned air exhaust lowers the outside air makeup that must be heated during the winter and cooled during the summer.

Figure 6 illustrates this modification. The concept recommended consists of a roof supply fan forcing approximately 12,000 cfm of unconditioned air through a single air duct and discharging 6,000 cfm under each of the two existing stove exhaust hoods.

The heating energy saved is estimated to be approximately 1400 million BTUs for an estimated heating oil savings of $15,670 per year. On the other hand, the additional electricity consumed by the fan (requiring 464 million BTUs of additional heat energy to generate the electricity) is estimated to be 40,000 KWhr per year for an additional electricity cost of approximately $1600, therefore, the net effect is a real energy savings of 936 million BTUs and a cost savings of $13,570 per year. The present worth of this savings over 25 years is $258,600.

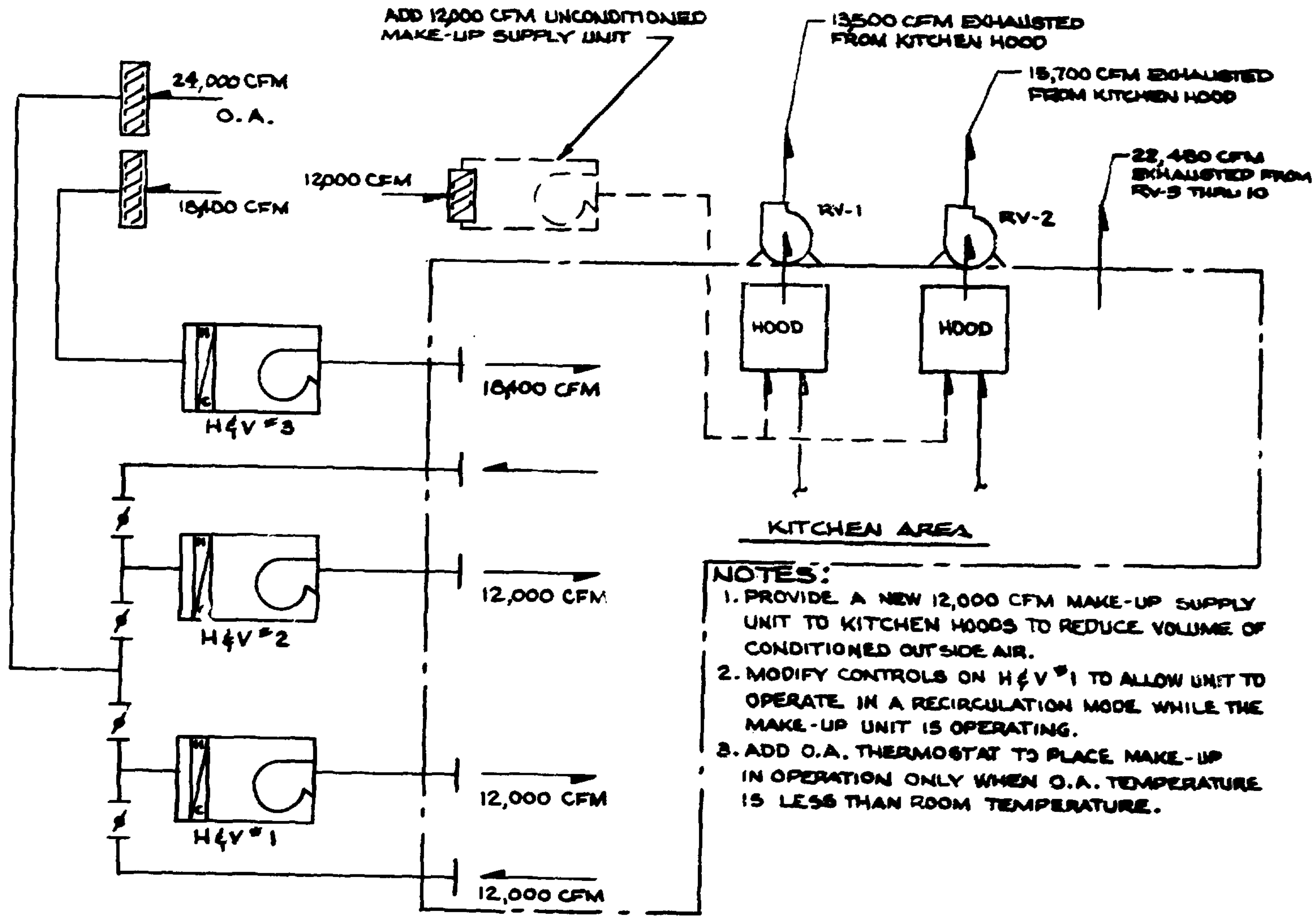
The Current Working Estimate (CWE) to install the fan system is $8000, with a total estimated capital investment of approximately $10,000. Therefore, the estimated simple payback period for this modification is less than one year, and the E/C ratio is approximately 117 million BTUs saved per $1000 invested.

5.3 Waste Heat Recovery Loop Between Exhaust and Inlet Ventilation Ducts

Figure 7 illustrates a waste heat recovery loop that extracts heat from the exhaust ventilation air and expels this heat back into the inlet air of the ventilation system. This waste heat recovery system consists of an air to water heat exchanger installed in the exhaust duct upstream of Fan F-7 and another heat exchanger installed in the inlet duct upstream of AC unit 2. A pump circulates a solution of water/glycol (to prevent freezing) through the exhaust heat exchanger where it extracts heat by cooling the exhaust flow. The water solution is then pumped through the inlet air heat exchanger where it raises the inlet air temperature. An expansion tank is required to accommodate the thermal expansion of the water and some controls are required to start and stop the circulating water pump based on inlet and exhaust air temperature.

The estimated annual heating energy saved by incorporating this waste heat recovery loop is approximately 760 million BTUs. of heating energy. The cost savings in heating oil associated with this energy savings is approximately $8,360 per year. However, the circulating water pump operating for approximately 4000 hours per year is estimated

KIMBOROUGH ARMY HOSPITAL ENERGY AUDIT



NOTES:

1. PROVIDE A NEW 12,000 CFM MAKE-UP SUPPLY UNIT TO KITCHEN HOODS TO REDUCE VOLUME OF CONDITIONED OUTSIDE AIR.
2. MODIFY CONTROLS ON H&V #1 TO ALLOW UNIT TO OPERATE IN A RECIRCULATION MODE WHILE THE MAKE-UP UNIT IS OPERATING.
3. ADD O.A. THERMOSTAT TO PLACE MAKE-UP IN OPERATION ONLY WHEN O.A. TEMPERATURE IS LESS THAN ROOM TEMPERATURE.

FIGURE 6

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Install induced air make-up system for kitchen exhaust hood

Economic Life 25 Yrs. Date Prepared 3/7/81 Prepared by R. W. Fell

COSTS

1.	Non-Recurring Initial Capital Costs:	
	a. CWE	$ 8,000
	b. Design	$ 2,000
	c.	$ 0
	d. Total	$ 10,000

BENEFITS

2.	Recurring Benefit/Cost Differential Other than Energy:	
	a. Annual Labor Decrease (+)/Increase (-)	$ - 500
	b. Annual Material Decrease (+)/Increase (-)	$ 0
	c. Other Annual Decrease (+)/Increase (-)	$ 0
	d. Total Costs	$ - 500
	e. 10% Discount Factor	$ 9.524
	f. Discounted Recurring Cost (d x e)	$ -4,750
3.	Recurring Energy Benefit/Costs:	
	a. Type of Fuel: Oil	
	(1) Annual Energy Decrease (+)/Increase (-)	1,400 MBTU
	(2) Cost per MBTU	$ 11.19
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 15,670
	(4) Differential Escalation Rate (8 %) Factor	20.015
	(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 313,550
	b. Type of Fuel: Electricity	
	(1) Annual Energy Decrease (+)/Increase (-)	- 40,000 KWH*
	(2) Cost per KWH	$ 0.04
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ - 1,600
	(4) Differential Escalation Rate (7 %) Factor	18.049
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ - 28,800
	c. Type of Fuel: -	
	(1) Annual Energy Decrease (+)/Increase (-)	
	(2) Cost per MBTU	$
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$
	(4) Differential Escalation Rate (- %) Factor	
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
	d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 284,750
4.	Total Benefits (Sum 2f+3d)	$ 280,000
5.	Discounted Benefit/Cost Ratio (Line 4/Line 1d)	28.0
6.	Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	936 MBTU
7.	E/C Ratio (Line 6 ÷ Line 1a/1000)	117
8.	Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 13,570
9.	Pay-Back Period ((Line 1a - Salvage)÷Line 8)	0.60 Years

*464 MBTU at generating station

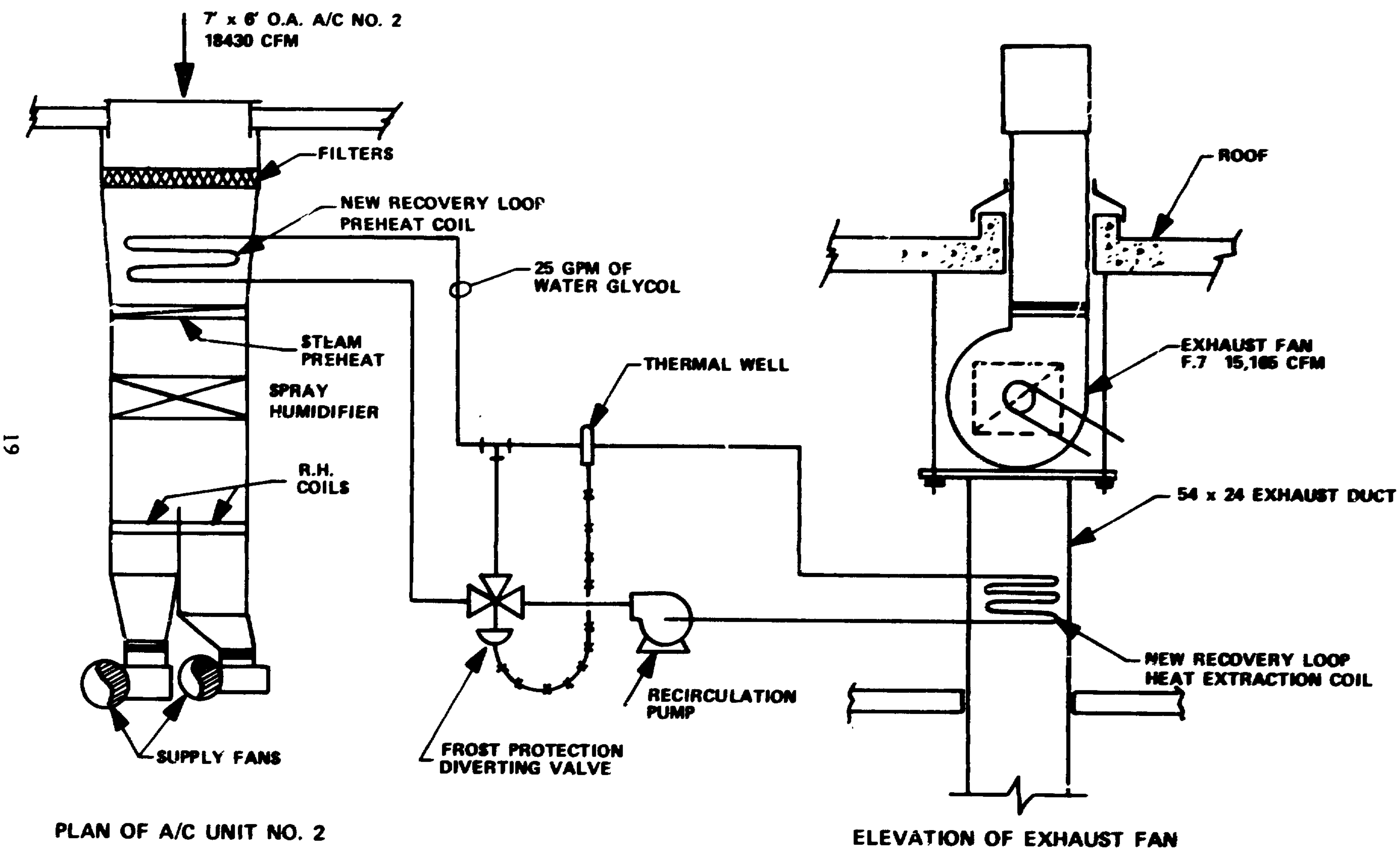


FIGURE 7
KIMBOROUGH ARMY HOSPITAL
HEAT RECOVERY COIL LOOP

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Install waste heat recovery loop between exhaust and intake ventilation ducts

Economic Life 25 Yrs. Date Prepared 3/25/81 Prepared by R. W. Fell/G.Lelko

COSTS

1.	Non-Recurring Initial Capital Costs:	
a.	CWE	$ 9,500
b.	Design (6% of installed cost)	$ 500
c.		$ 0
d.	Total	$ 10,000

BENEFITS

2.	Recurring Benefit/Cost Differential Other than Energy:	
a.	Annual Labor Decrease (+)/Increase (-)	$ - 500
b.	Annual Material Decrease (+)/Increase (-)	$ 0
c.	Other Annual Decrease (+)/Increase (-)	$ 0
d.	Total Costs	$ - 500
e.	10% Discount Factor	$ 9.524
f.	Discounted Recurring Cost (d x e)	$ -4,750
3.	Recurring Energy Benefit/Costs:	
a.	Type of Fuel: Oil	
(1)	Annual Energy Decrease (+)/Increase (-)	+ 760 MBTU
(2)	Cost per MBTU	$ 11.19
(3)	Annual Dollar Decrease/Increase ((1)x(2))	$ 8,360
(4)	Differential Escalation Rate (8 %) Factor	20.050
(5)	Discounted Dollar Decrease/Increase (3)x(4)	$ 167,618
b.	Type of Fuel: Electricity	
(1)	Annual Energy Decrease (+) Increase (-)	- 44,806* KWH
(2)	Cost per KWH	$ 0.04
(3)	Annual Dollar Decrease/Increase ((1)x(2))	$ 1,792
(4)	Differential Escalation Rate (7 %) Factor	18.049
(5)	Discounted Dollar Decrease/Increase ((3)x(4))	$ -32,343
c.	Type of Fuel:	
(1)	Annual Energy Decrease (+)/Increase (-)	
(2)	Cost per MBTU	$
(3)	Annual Dollar Decrease/Increase ((1)x(2))	$
(4)	Differential Escalation Rate (%) Factor	
(5)	Discounted Dollar Decrease/Increase ((3)x(4))	$
d.	Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 135,275
4.	Total Benefits (Sum 2f+3d)	$ 130,525
5.	Discounted Benefit/Cost Ratio (Line 4/Line 1d)	13.0
6.	Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	240 MBTU
7.	E/C Ratio (Line 6 ÷ Line 1a/1000)	25
8.	Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 6,068
9.	Pay-Back Period ((Line 1a - Salvage)÷Line 8)	1.6 Years

*520 MBTU at generating station

to consume an additional 3,000 KWhrs; also, the additional fan horsepower required to accommodate the added air pressure drop across the two heat exchangers is estimated to consume an additional 42,000 KWhrs. Therefore, the total additional electricity cost is estimated to be $1792 per year and an additional 520 million BTUs of heat is required to generate the electricity. The net energy and cost savings for this heat recovery system is estimated to be 240 million BTUs and $6068 per year.

The CWE for this heat recovery system is approximately $9500 with a total estimated installed cost of $10,000. Therefore, the simple payback time is approximately 1.6 years and the E/C ratio is estimated to be 25.

5.4 Additional Insulation to the Roof of the Old Hospital

By adding two-inches of additional insulation on top of the drop ceiling that exists beneath the roof of the old hospital an estimated savings of 370 million BTUs of heating energy will be realized. This translates to a cost savings of approximately $4140 per year. The estimated installed cost for this insulation to cover the 37,764 ft^2 of ceiling area is approximately $19,000. This yields a simple payback period of 4.6 years and a E/C ratio of approximately 19.6.

5.5 Repair of Leaking Condensate Return Sump Tank and Pumps for the New Addition

The condensate return tank and pumps serving the new addition are leaking approximately four gallons per hour of condensate return water. The leakage is estimated to result in an increase in makeup water of approximate 9600 gallons and an increase in heating energy of 9.6 million BTUs per heating season. The cost savings for fixing this leak is, therefore, estimated to be $106 for fuel and $29 for makeup water for a total of $135 saved per heating season. No capital investment is required.

5.6 Repair Steam Leakage from the Domestic Hot Water System

Steam is leaking from the domestic hot water heaters at an estimated rate of approximately 5 pounds per hour. This leakage rate, if not fixed, will unnecessarily consume an additional 43.8 million BTUs of heating energy and approximately 5300 gallons of water each year. If the hot water system is repaired to stop the steam leakage, the annual cost savings estimated to be $481 for heating oil and $16 for makeup water for a total savings of $497, could be realized. No capital investment is required.

6.0 ENERGY SAVINGS MODIFICATION WITH MODERATE ECONOMIC INCENTIVE

6.1 Additional Insulation to the Roof of the New Clinic without Fan Cycling

If the fan cycling modification presented in Section 5.1 is not incorporated, then adding insulation between the roof and drop ceiling of the new addition offers some merit. For example, adding four inches of blown insulation on top of the drop ceiling will save an estimated 540 million BTUs of heat during the winter and 47 million BTUs of cooling (i.e., 3443 KWhr). The net effect is annual cost savings of approximately $5940 for heating and $138 for cooling, totaling $6078.

The estimated cost for blowing four inches of insulation on the top of the drop ceiling is $28,000. Thus the simple payback is estimated to be 4.6 years, and the E/C ratio is estimated to be 20.7.

6.2 Additional Insulation to the Roof of the New Clinic with Fan Cycling

If the fan cycling control scheme as identified in Section 5.1 is incorporated, then the addition of more insulation in the drop ceiling has marginal economic incentive. For example, adding two inches of blown insulation will result in an incremental heating energy savings of 239 million BTUs but an additional air conditioning electrical consumption of 2420 KWhr. The incremental annual energy and cost savings for this case is, therefore, 21 million BTUs and approximately $2500.

The estimated cost for installing the insulation on the ceiling is $16,800. This yields a simple payback of approximately seven years and an E/C ratio of 12.5. These economic merit figures are considered marginally acceptable.

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Adding 2" insulation to the roof of old hospital

Economic Life 25 Yrs. Date Prepared 3/25/81 Prepared by G. A. Lelko

COSTS

1. Non-Recurring Initial Capital Costs:
   - a. CWE $ 19,000
   - b. Design $ 0
   - c. ______ $ 0
   - d. Total $ 19,000

BENEFITS

2. Recurring Benefit/Cost Differential Other than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ 0
   - b. Annual Material Decrease (+)/Increase (-) $ 0
   - c. Other Annual Decrease (+)/Increase (-) $ 0
   - d. Total Costs $ 0
   - e. 10% Discount Factor $ 0
   - f. Discounted Recurring Cost (d x e) $ 0

3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Oil
     - (1) Annual Energy Decrease (+)/Increase (-) + 370 MBTU
     - (2) Cost per MBTU $ 11.19
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 4,140
     - (4) Differential Escalation Rate (8 %) Factor 20.050
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ 83,007
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) + 271*KWH
     - (2) Cost per KWH $ .04
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 10.84
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 195.65
   - c. Type of Fuel: ______
     - (1) Annual Energy Decrease (+)/Increase (-) ______
     - (2) Cost per MBTU $ ______
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______
     - (4) Differential Escalation Rate (___ %) Factor ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   - d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 83,202

4. Total Benefits (Sum 2f+3d) $ 83,202
5. Discounted Benefit/Cost Ratio (Line 4/Line 1d) 4.38
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)) 373 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 19.6
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)) $ 4,150
9. Pay-Back Period ((Line 1a - Salvage)÷Line 8) 4.6 Years

*3.14 MBTU at generating station

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade Army Hospital **FY** 1981

Project: Add 4" insulation to drop ceiling of new clinic

Economic Life 25 **Yrs.** **Date Prepared** 3/7/81 **Prepared by** R.W. Fell

COSTS

1.	Non-Recurring Initial Capital Costs:	
	a. CWE	$ 28,000
	b. Design	$ 0
	c.	$ 0
	d. Total	$ 28,000

BENEFITS

2.	Recurring Benefit/Cost Differential Other than Energy:	
	a. Annual Labor Decrease (+)/Increase (-)	$ 0
	b. Annual Material Decrease (+)/Increase (-)	$ 0
	c. Other Annual Decrease (+)/Increase (-)	$ 0
	d. Total Costs	$ 0
	e. 10% Discount Factor	$ 0
	f. Discounted Recurring Cost (d x e)	$ 0
3.	Recurring Energy Benefit/Costs:	
	a. Type of Fuel: Oil Heating	
	(1) Annual Energy Decrease (+)/Increase (-)	540 MBTU
	(2) Cost per MBTU	$ 11 MBTU
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 5,940
	(4) Differential Escalation Rate (8 %) Factor	20,050
	(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 119,100
	b. Type of Fuel: Electricity	
	(1) Annual Energy Decrease (+)/Increase (-)	3,443 KWHR*
	(2) Cost per MBTU	$ .04
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 138
	(4) Differential Escalation Rate (7 %) Factor	18,049
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ 2,490
	c. Type of Fuel: -	
	(1) Annual Energy Decrease (+)/Increase (-)	
	(2) Cost per MBTU	$
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$
	(4) Differential Escalation Rate (- %) Factor	
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
	d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 121,590
4.	Total Benefits (Sum 2f+3d)	$ 121,590
5.	Discounted Benefit/Cost Ratio (Line 4/Line 1d)	4.3
6.	Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	579 MBTU
7.	E/C Ratio (Line 6 ÷ Line 1a/1000)	20.7
8.	Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 6,078
9.	Pay-Back Period ((Line 1a - Salvage)÷Line 8)	4.6 Years

*39 MBTU at generating station

'NOMIC ANALYSIS SUMMARY

Location: Ft. Meade Army Hospital FY 1981

Project: Install 2" of insulation with fan cycling for the new addition clinic

Economic Life 25 Yrs. Date Prepared 3/7/81 Prepared by R. W. Fell

COSTS

1. Non-Recurring Initial Capital Costs:
   - a. CWE $ 16,800
   - b. Design $ 0
   - c. ______ $ 0
   - d. Total $ 16,800

BENEFITS

2. Recurring Benefit/Cost Differential Other than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ 0
   - b. Annual Material Decrease (+)/Increase (-) $ 0
   - c. Other Annual Decrease (+)/Increase (-) $ 0
   - d. Total Costs $ 0
   - e. 10% Discount Factor $ 0
   - f. Discounted Recurring Cost (d x e) $ 0

3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Heating Oil
     - (1) Annual Energy Decrease (+)/Increase (-) 239 MBTU/Yr
     - (2) Cost per MBTU $ 11
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 2,629
     - (4) Differential Escalation Rate (8 %) Factor 20.05
     - (5) Discounted Dollar ~~Decrease~~/Increase (3)x(4) $ 52,711
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) - 2,420 KWHR*
     - (2) Cost per MBTU $ .04
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ - 100
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/~~Increase~~ ((3)x(4)) $ - 1,804
   - c. Type of Fuel: -
     - (1) Annual Energy Decrease (+)/Increase (-)
     - (2) Cost per MBTU $
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $
     - (4) Differential Escalation Rate (- %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 50,907

4. Total Benefits (Sum 2f+3d) $ 50,907
5. Discounted Benefit/Cost Ratio (Line 4/Line 1d) 3.03
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)) 211 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 12.5
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)) $ 2,529
9. Pay-Back Period ((Line 1a - Salvage)÷Line 8) 6.6 Years

*28 MBTU at generating station

CALCULATIONS

CLIENT	CALC. No.
FESA	5398-M-01

SUBJECT
Install Microprocessor to Cycle Air Handling Fans on New Addition

PROBLEM:

Evaluate the merits of cycling the fans based on time of day, days per week, and temperature control for the new addition.

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

DOE-2 computer runs were employed to evaluate the problem.

Approximately 60 KW of fans are candidates for control.

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

Measured power consumption indicates a 70 KW steady load that could be controlled by a microprocessor

CHECKER'S REMARKS:

CONCLUSIONS.

Heating energy saved	≈	1570 MBTU/Yr
Electricity saved	≈	380,000 KW Hr/Yr
Total energy saved	≈	5755 MBTU/Yr
Annual $ saved	≈	$32,780
E/C ratio	≈	480
Simple payback period	≈	4 Years

CHECKER'S REMARKS:

CALCULATED BY R. W. Fell	DATE 3/7/81
CHECKED BY G. A. Lelko	ATE 7/8/81

ED-501 (2/80)

NUS CORPORATION

Page 1 of 2

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-01 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. LELKO

PROBLEM:

EVALUATE THE MERITS of CYCLING THE FANS IN THE NEW CLINIC BASED ON TIME of DAY, DAYS PER WEEK AND TEMPERATURE CONTROL FOR THE NEW ADDITION.

SOLUTION:

BASED ON RESULTS of DOE II Computer Run:

	HEATING 10^6 BTU/YR	COOLING 10^6 BTU/YR	Electric ENERGY *
BASE	2680	1479	828535 Kwh/yr
w/ 2" Ceiling Insulation	2275	1446	
w/ 4" Ceiling Insulation	2147	1432	
w/ 6" Ceiling Insulation	2079	1424	
Thermostatic Fan Reschad.	1111	922	662,649 Kwh/yr

* BASED ON 29 KW of fan Power

Heating Energy Saved By Fan Cycling = $(2680-1111)\times 10^6$ BTU/yr

$= 1569 \times 10^6$ BTU/yr

Cooling Energy Saved By Fan Cycling = $(1479-922)\times 10^6$ BTU/yr

$= 557 \times 10^6$ BTU/yr

Electricity Saved in Cooling $= \dfrac{557 \times 10^6 \text{ BTU/yr}}{4.4} \cdot \dfrac{1 \text{ KWH}}{3412 \text{ BTU}} = 37,101$

$\approx 37,000$ KWH/yr

NUS CORPORATION

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-01 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. Lelko

Electricity Saved via fans @ 29 KW =

$$(828,535 - 662,649)\ \text{KWH/yr} = 165,886\ \text{KWH/yr}$$

It was later determined that the computer input of 29 KW for fan horsepower was incorrect and should have been 60 KW. Therefore the estimated electricity saved in fan horsepower is given by:

$$\text{Total Electricity saved} = 165,886 \times \frac{60}{29} \approx 343,210\ \text{KWH}$$

The Cost Savings reflected by the above energy Savings are given by:

Heating Oil Costs:

$$\frac{1569 \times 10^6\ \text{BTU/yr}}{.83} \times \frac{1\ \text{GAL}}{140,000\ \text{BTU}} \times \$1.30/\text{gal} = \$17550/\text{yr}$$

where .83 is the estimated Boiler efficiency and 140,000 BTU/gal is a typical heating value for No2 oil

Electricity Costs:

$$(37,000 + 343,210)\ \text{KWH/yr} \times \$.04/\text{KWH} =$$

$$380,210\ \text{KWH/yr} \times \$.04/\text{KWH} = \$15,210/\text{yr}$$

Total Cost Savings =

$$\$17,550/\text{yr} + \$15,210/\text{yr} = \$32,760/\text{yr}$$

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Install microprocessor to cycle air handling fans on new addition

Economic Life 10 Yrs. Date Prepared 3/7/81 Prepared by R. W. Fell

COSTS

1. Non-Recurring Initial Capital Costs:
   - a. CWE $ 12,000
   - b. Design $ 0
   - c. ________ $ 0
   - d. Total $ 12,000

BENEFITS

2. Recurring Benefit/Cost Differential Other than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ ____
   - b. Annual Material Decrease (+)/Increase (-) $ ____
   - c. Other Annual Decrease (+)/Increase (-) $ ____
   - d. Total Costs $ ____
   - e. 10% Discount Factor $ ____
   - f. Discounted Recurring Cost (d x e) $ ____

3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Oil
     - (1) Annual Energy Decrease (+)/Increase (-) 1,570 MBTU
     - (2) Cost per MBTU $ 11.19
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 17,570
     - (4) Differential Escalation Rate (8 %) Factor 9.136
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ 160,520
   - Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 380,210 KWH*
     - (2) Cost per KWH $ 0.04
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 15,210
     - (4) Differential Escalation Rate (7 %) Factor 8.737
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 132,890
   - c. Type of Fuel: ________
     - (1) Annual Energy Decrease (+)/Increase (-) ____
     - (2) Cost per MBTU $ ____
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____
     - (4) Differential Escalation Rate (___%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 293,410

4 Total Benefits (Sum 2f+3d) $ 293,410

Discounted Benefit/Cost Ratio (Line 4/Line 1d) 24.4

Total Annual Energy Savings (3a(1)+3b(1)+3c(1)) 5,755 MBTU

. E/C Ratio (Line 6 ÷ Line 1a/1000) 480

?. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)) $ 32,780

9. Pay-Back Period ((Line 1a - Salvage)÷Line 8) 0.4 Years

*4,185 MBTU at generating station

CLIENT	CALC. No.
FESA	5398-M-02

SUBJECT Induced Air Makeup System for Kimborough Army Hospital Kitchen

PROBLEM:

Evaluate merits of an induced air makeup system for the kitchen exhaust hoods at the Kimborough Army Hospital

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

Non-conditioned air is introduced directly underneath the hoods to reduce the amount of conditioned air that would be exhausted out the building

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

See calculations

CHECKER'S REMARKS:

CONCLUSIONS:

936 MBTU are saved		
Expected cost savings	≈	$13,570/Yr
E/C ratio	≈	117
Simple payback period	≈	0.6 Year

CHECKER'S REMARKS:

CALCULATED BY R. W. Fell	DATE 3/7/81
CHECKED BY G. A. Lelko	DATE 7/8/81

ED-501 (2/80)

CLIENT FESA FILE NO. 5398-M-02 BY BOB FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. LELKO

PROBLEM: EVALUATE THE MERITS OF AN INDUCED AIR MAKEUP SYSTEM FOR THE KITCHEN EXHAUST HOOD AT THE KIMBOROUGH ARMY HOSPITAL

SOLUTION:

1. CONDITIONED AIR SAVED = 12000 CFM

2. HEATING ENERGY SAVED:

$$12000\ \text{CFM} \times 1.08\ \frac{\text{BTU}}{\text{HR-CFM}} \times 4200^\circ \frac{\text{-DAYS}}{\text{SEASON}} \times 24\ \frac{\text{HR}}{\text{DAY}} \times$$

$$\times 0.79 \times 1.36 = 1.4 \times 10^9\ \text{BTU/SEASON SAVED}$$

where 0.79 = HEAT LOSS VS. DEGREE DAY INTERIM FACTOR (C_D)
1.36 = PART LOAD CORRECTION FACTOR (C_F)
(BOTH C_D AND C_F ARE FROM ASHRAE MODIFIED DEGREE DAY METHOD, REF 1976 ASHRAE SYSTEMS HANDBOOK)

3. COST SAVINGS FOR HEATING OIL

$$\frac{1.4 \times 10^9\ \text{BTU/SEASON}}{140{,}000\ \text{BTU/GAL}} \times \frac{1}{.83} \times \$1.30/\text{GAL}$$

\$15,670/YR

4. POWER CONSUMED BY FAN
APPROXIMATELY 10 HP WILL BE REQUIRED TO DRIVE THE FANS TO CIRCULATE 12000 CFM
BECAUSE THE SYSTEM WILL FUNCTION ONLY IN WINTER, IT WILL BE ASSUMED TO RUN APPROXIMATELY 4000 HOURS/YR.

A-8

NUS CORPORATION

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-02 BY R.W. FELL

SUBJECT Kimbrough Hospital Energy Audit Checked By G.A. Lelko

Assuming motor efficiency of 75%, the electric power consumption for a 10 HP motor is estimated to be:

$$10 \text{ HP} \times 746 \frac{\text{WATTS}}{\text{HP}} \times \frac{1}{.75} \approx 10{,}000 \text{ WATTS}$$

The estimated electric energy consumed is therefore:

$$10{,}000 \text{ WATTS} \times 4000 \text{ HRS}/\text{YR} = 40{,}000 \text{ KWH}/\text{YR}$$

5. Cost of additional electricity consumed

$$\text{Cost} = 40{,}000 \text{ KWH}/\text{YR} \times \$.04/\text{KWH} = \$1600/\text{YR}$$

6. Additional energy consumption required at generating station to produce the electricity:

$$\text{Energy} = 40{,}000 \text{ KWH}/\text{YR} \times 11600 \text{ BTU}/\text{KWH} = 4.64 \times 10^{8} \text{ BTU}/\text{YR}$$

where 11,600 BTU/KWH is the assumed heat rate of the electric generating facility.

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Install induced air make-up system for kitchen exhaust hood

Economic Life 25 Yrs. Date Prepared 3/7/81 Prepared by R. W. Fell

COSTS

1.	Non-Recurring Initial Capital Costs:	
	a. CWE	$ 8,000
	b. Design	$ 2,000
	c.	$ 0
	d. Total	$ 10,000

BENEFITS

2.	Recurring Benefit/Cost Differential Other than Energy:	
	a. Annual Labor Decrease (+)/Increase (-)	$ - 500
	b. Annual Material Decrease (+)/Increase (-)	$ 0
	c. Other Annual Decrease (+)/Increase (-)	$ 0
	d. Total Costs	$ - 500
	e. 10% Discount Factor	$ 9.524
	f. Discounted Recurring Cost (d x e)	$ -4,750
3.	Recurring Energy Benefit/Costs:	
	a. Type of Fuel: Oil	
	(1) Annual Energy Decrease (+)/Increase (-)	1,400 MBTU
	(2) Cost per MBTU	$ 11.19
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 15,670
	(4) Differential Escalation Rate (8 %) Factor	20.015
	(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 313,550
	b. Type of Fuel: Electricity	
	(1) Annual Energy Decrease (+)/Increase (-)	- 40,000 KWH*
	(2) Cost per KWH	$ 0.04
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ - 1,600
	(4) Differential Escalation Rate (7 %) Factor	18.049
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ - 28,800
	c. Type of Fuel: -	
	(1) Annual Energy Decrease (+)/Increase (-)	
	(2) Cost per MBTU	$
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$
	(4) Differential Escalation Rate (- %) Factor	
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
	d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 284,750
4.	Total Benefits (Sum 2f+3d)	$ 280,000
5.	Discounted Benefit/Cost Ratio (Line 4/Line 1d)	28.0
6.	Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	936 MBTU
7.	E/C Ratio (Line 6 ÷ Line 1a/1000)	117
8.	Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 13,570
9.	Pay-Back Period ((Line 1a - Salvage)÷Line 8)	0.60 Years

*464 MBTU at generating station

CLIENT	CALC. No.
FESA	5398-M-03

SUBJECT
Waste Heat Recovery Loop - Kimborough Army Hospital

PROBLEM:

Evaluate a run-around ventilation exhaust to ventilation inlet heat recovery loop

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

Computer code, DOE-2, was employed to predict the energy performance of the old hospital section with a waste heat recovery loop

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

Included with the calculations

CHECKER'S REMARKS:

CONCLUSIONS:

Total energy saved	≈	240 MBTU
Simple payback period	≈	1.6 Years
E/C ratio	≈	25

CHECKER'S REMARKS:

CALCULATED BY R. W. Fell	DATE 3/25/81
CHECKED BY G. A. Lelko	DATE 7/8/81

ED-501 (2/80)

NUS CORPORATION

DATE 3/25/81

CLIENT FESA FILE NO. 5398-M-03 BY R.W. FELL

SUBJECT KIMBOROUGH HOSPITAL ENERGY AUDIT Checked By G.A. LELKO

HEAT RECOVERY LOOP

1. ENERGY DIFFERENTIAL FROM HEAT RECOVERY LOOP, BASED UPON DOE-II COMPUTER RUNS.

	BASE CASE	w/ HEAT RECOVERY LOOP
HEATING	12131 MBTU/YR	11372 MBTU/YR
COOLING	4758 MBTU/YR	4753 MBTU/YR

HEATING ENERGY SAVED = 12131 − 11372 = 759.9 MBTU/YR

COOLING ENERGY SAVED = 4758 − 4753 = 5 MBTU/YR

2. POWER CONSUMED BY CIRCULATING WATER PUMP

2.1 Capacity of heat recovery loop

$$\dot{Q} = 760 \frac{MBTU}{SEASON} \times \frac{SEASON}{6\ months} \times \frac{MONTH}{30\ DAYS} \times \frac{DAY}{24\ HRS.} \times 2$$

$$\approx 351{,}800 \frac{BTU}{HR}$$

2.2 Circulating water pump flow rate

$$\dot{Q} = \dot{m} c_p \Delta T$$

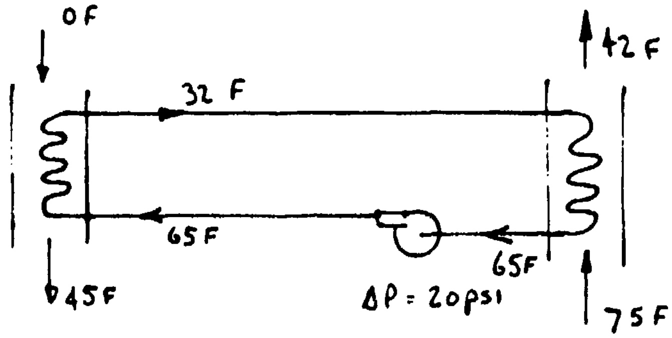
Assume ΔT = 65F − 32F = 33 F

NUS CORPORATION

DATE 3/25/81

CLIENT FESA FILE NO. 5398-M-03 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. Lelko



$$\dot{m} = \frac{351{,}800\ \text{BTU/HR}}{\frac{1\ \text{BTU}}{\text{LB-F}} \times 33\ \text{F}} \times \frac{1\ \text{hR}}{60\ \text{min}} \times \frac{1\ \text{GAL}}{8.3\ \text{LB}} = 21.4\ \text{GAL}$$

Assume the pump differential = 20psi

Then pump power =

$$\text{Power} = \frac{\dot{m}\,\Delta P}{\rho}$$

$$= \frac{21.4\ \frac{\text{GAL}}{\text{HR}} \times 8.3\ \frac{\text{LB}}{\text{GAL}}}{62.4\ \frac{\text{LB}}{\text{FT}^3}} \times 20\ \frac{\text{LB}}{\text{IN}^2} \times 144\ \frac{\text{IN}^2}{\text{FT}^2} \times \frac{1\ \text{min}}{60\text{sec}}$$

$$\times \frac{1\ \text{hp}}{550\ \frac{\text{FT-LB}}{\text{sec}}} \approx .25\ \text{HP}$$

Assume a 1 horsepower motor is used to drive the pump.

CLIENT FESA FILE NO. 5398-M-03 BY FELL

SUBJECT KIMBOROUGH HOSPITAL ENERGY AUDIT Checked By G.A. LELKO

The heat recovery loop will operate approximately 4000 HRS per year. Therefore, pump motor energy consumption is given by:

$$E/_{pump} = 1\ hp \times 746\ \frac{WATTS}{hp} \times 4000\ hrs \times \frac{1\ KW}{1000\ WATTS} =$$

$$2984\ KWH/YR$$

3. Additional fan Power req'd to overcome added pressure loss:

$$Power = \dot{m}\ C_p\ \Delta T$$

3.1 Exhaust FAN

Exhaust Fan $\approx$ 16000 CFM

$$\Delta T/_{\substack{ACROSS \\ FAN}} = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} - T_1$$

where T_1 = FAN INLET TEMP
P_1 = FAN INLET PRESS
P_2 = FAN OUTLET PRESS

CLIENT FESA FILE NO. 5398-M-03 BY FELL

SUBJECT Kimborough Hospital ENERGY AUDIT Checked By G.A. LELKO

For an additional ΔP added to the fan discharge pressure due to the insertion of heat recovery coils, the incremental increase in discharge temperature can be estimated to be:

$$\Delta T_{\text{increase}} \approx T_1 \left(\frac{P_2 + \Delta P}{P_1}\right)^{\frac{K-1}{K}} - T_1 \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}}$$

Assume $P_1 = 14.3$ psia

$P_2 = P_1 + 7$ in-H₂O $= 14.3 \text{ psia} + \frac{7 \text{ in-H}_2\text{O}}{27.6 \left(\frac{\text{in-H}_2\text{O}}{\text{psia}}\right)}$

(P_2 = fan discharge pressure before adding heat recovery coils)

$P_3 = P_2 + \Delta P$ = fan discharge pressure after adding heat recovery coils

Assume $\Delta P \Big|_{\text{heat recovery coils}} = 1$ in-H_2O

$P_3 = 14.3 + 7/27.6 + 1/27.6 = (14.3 + 8/27.6)$ psia

T_1 = fan inlet temperature $\approx 80F = 540R$

$$\Delta T\Big|_{\substack{\text{incr.} \\ \text{isentropic}}} = 540 \left(\frac{14.3 + 8/27.6}{14.3}\right)^{\frac{1.4-1}{1.4}} - 540\left(\frac{14.3 + 7/27.6}{14.3}\right)^{\frac{1.4-1}{1.4}}$$

$= 543.1\ R - 542.7 = .4\ R$

CLIENT FESA FILE NO. 5398-M-03 BY R.W. FELL

SUBJECT KIMBOROUGH HOSPITAL ENERGY AUDIT Checked By G.A. LELKO

INCREASE IN ISENTROPIC POWER:

$$\Delta P\Big|_{isentropic} = \dot{m}\, C_p\, \Delta T\Big|_{isentropic}$$

$$= 16\,000 \frac{FT^3}{MIN} \times .075 \frac{LBm}{FT^3} \times .25 \frac{BTU}{LBm\text{-}R} \times 4R \times$$

$$\times \frac{1 \text{ watt-hr}}{3.412 \text{ BTU}} \times \frac{1 \text{ hp}}{746 \text{ watts}} \times 60 \frac{\text{min}}{\text{hr}}$$

$$\Delta P\Big|_{isentropic} = 2.83 \text{ hp}$$

Assume that the fan & motor together convert electric power to AIR FLOW with an efficiency of 65%. Then THE power demand of the motor WILL BE:

$$\frac{2.83 \text{ hp}}{.65} \times \frac{746 \text{ watts}}{\text{hp}} \approx 3282 \text{ watts}$$

The ENERGY CONSUMED BY continuous RUNNING WILL BE given by:

$$\text{Energy} = 3282 \text{ watts} \times 8760 \frac{\text{hrs}}{\text{yr}} \times \frac{1 \text{ KW}}{1000 \text{ watts}}$$

$$= 28,750 \text{ KWhr/yr}$$

CLIENT FESA FILE NO. 5398-M-03 BY FELL
SUBJECT Kimborough Hospital Energy Audit Checked By L. ELKO

3.2 Supply Fan

Because of larger flow across this section, assume the differential pressure across the inlet heat recovery coil to be:

$$\Delta P_{inlet} = 0.5 \text{ in-}H_2O$$

Supply Fan Flow = 19000 ft^3/min

$$\text{Power} = \dot{m} C_p \Delta T$$

$$\Delta T \Big|_{\substack{\text{increase in} \\ \text{Supply Fan} \\ \text{Discharge Temp}}} = T_1 \left(\frac{P_2 + \Delta P}{P_1}\right)^{\frac{K-1}{K}} - T_1 \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}}$$

where P_1 = inlet pressure
P_2 = Fan outlet pressure before adding recovery coil
ΔP = pressure drop across recovery coil

Assume: $T_1 = 60°F = 460 + 60 = 520R$

$P_1 = 14.3$ psia
$P_2 = 14.3$ psia + $7/27.6$ psia

$\Delta P = 0.5$ in-H_2O

$$\Delta T = 520\left(\frac{14.3 + \frac{7.5}{27.6}}{14.3}\right)^{\frac{1.4-1}{1.4}} - 520\left(\frac{14.3 + 7/27.6}{14.3}\right)^{\frac{1.4-1}{1.4}}$$

$$= 522.80R - 522.62R = .18R$$

CLIENT FESA FILE NO. 5398-M-03 BY FELL

SUBJECT KIMBOROUGH HOSPITAL ENERGY AUDIT Checked By LELKO

Additional supply fan power is given by:

$$\Delta \text{Power}\Big|_{\text{Isentropic}} = \dot{m} C_p \Delta T =$$

$$= 19000 \frac{FT^3}{min} \times .075 \frac{LBm}{FT^3} \times .24 \frac{BTU}{LBm\text{-}R} \times .18R \times \frac{1\ \text{watt-hr}}{3.412\ BTU}$$

$$\times \frac{1\ hp}{746\ watt} \times \frac{60\ min}{hr}$$

$$\Delta \text{Power}\Big|_{\text{isentropic}} = 1.45\ hp$$

Assume 72% total fan efficiency (motor plus fan) due to the larger motor size. Then total increase in Electrical power will be approximately:

$$P_{Elec} = \frac{1.45}{.72} \approx 2\ hp$$

Electric energy consumed =

$$2\ hp \times 746 \frac{watts}{hp} \times 8760 \frac{hr}{yr} = 13069\ Kwh$$

4.0 Total Energy consumed by the heat recovery loop

Exhaust Fans	28753	KwHr
Supply Fans	13069	Kwhr
Water Pump	2984	Kwhr

Total Energy Consumed 44806 kwhr

CLIENT FESA FILE NO. 5398-M-03 BY FELL

SUBJECT Kimborough Hospital Energy Audit Checked By LELKO

5. Electricity Cost

$$44806 \text{ KWH/YR} \times \$.04/\text{KWH} = \$1792.20/\text{YR}$$

6. Additional fuel required at the Electric generating station:

$$\text{Fuel}\Big|_{\text{Power Plant}} = 44{,}806 \text{ Kwh/yr} \times 11600 \text{ BTU/KWH}$$

$$= 519.7 \text{ mBTU/YR}$$

where: 11600 BTU/KWH is the assumed heat rate of the generating station.

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Install waste heat recovery loop between exhaust and intake ventilation ducts

Economic Life 25 Yrs. Date Prepared 3/25/81 Prepared by R. W. Fell/G.Lelko

COSTS	
1. Non-Recurring Initial Capital Costs:	
a. CWE	$ 9,500
b. Design (6% of installed cost)	$ 500
c.	$ 0
d. Total	$ 10,000
BENEFITS	
2. Recurring Benefit/Cost Differential Other than Energy:	
a. Annual Labor Decrease (+)/Increase (-)	$ - 500
b. Annual Material Decrease (+)/Increase (-)	$ 0
c. Other Annual Decrease (+)/Increase (-)	$ 0
d. Total Costs	$ - 500
e. 10% Discount Factor	$ 9.524
f. Discounted Recurring Cost (d x e)	$ -4,750
3. Recurring Energy Benefit/Costs:	
a. Type of Fuel: Oil	
(1) Annual Energy Decrease (+)/Increase (-)	+ 760 MBTU
(2) Cost per MBTU	$ 11.19
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 8,360
(4) Differential Escalation Rate (8 %) Factor	20.050
(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 167,618
b. Type of Fuel: Electricity	
(1) Annual Energy Decrease (+)/Increase (-)	- 44,806* KWH
(2) Cost per KWH	$ 0.04
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 1,792
(4) Differential Escalation Rate (7 %) Factor	18.049
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ -32,343
c. Type of Fuel:	
(1) Annual Energy Decrease (+)/Increase (-)	
(2) Cost per MBTU	$
(3) Annual Dollar Decrease/Increase ((1)x(2))	$
(4) Differential Escalation Rate (%) Factor	
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 135,275
4. Total Benefits (Sum 2f+3d)	$ 130,525
5. Discounted Benefit/Cost Ratio (Line 4/Line 1d)	13.0
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	240 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000)	25
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 6,068
9. Pay-Back Period ((Line 1a - Salvage)÷Line 8)	1.6 Years

*520 MBTU at generating station

CLIENT	CALC. No.
FESA	5398-M-04

SUBJECT
2" Insulation to Ceiling of Old Section of Kimborough Army Hospital

PROBLEM:

Evaluate adding 2" of insulation to the top of the drop ceiling beneath the roof of the Kimborough Army Hospital (old section).

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

DOE-2 computer runs were made to simulate the performance of the hospital before and after the insulation was added.

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS

Area of the roof is 37764 Ft^2

CHECKER'S REMARKS:

CONCLUSIONS:

Total energy saved	≈	373 MBTU
Simple payback period	≈	4.6 Years
E/C ratio	≈	19.6

CHECKER'S REMARKS:

CALCULATED BY	DATE
R. W. Fell	3/25/81
CHECKED BY	**DATE**
G. A. Lelko	7/8/81

ED-501 (2/80)

CLIENT FESA FILE NO. 5398-M-04 BY R. W. FELL

SUBJECT KIMBOROUGH HOSPITAL ENERGY AUDIT Checked By G. A. LELKO

PROBLEM: EVALUATE THE ADDITION of 2" INSULATION TO THE OF THE OLD HOSPITAL SECTION.

1. FROM DOE-II COMPUTER RUNS, the following TABLE SUMMARIZES THE BEFORE AND AFTER HEATING AND COOLING LOADS.

	PRESENT (MBTU/YR)	After Addition of 2" Insulation (MBTU/YR)	SAVINGS (MBTU/YR)
HEATING	12,131	11,761	370
COOLING	4753.3	4749.6	3.7

HEAT ENERGY SAVED = 370 MBTU

FUEL COST SAVING = 370 MBTU × \$11.19/MBTU = \$4140

Electricity Saved $= \frac{3.7 \times 10^6}{4} \times \frac{1}{3412} = 271$ KWH/YR

where 4 = Coefficient of performance of chiller

FUEL SAVED AT GENERATING Station =

271 KWH/YR × 11600 BTU/KWH =

3.14 MBTU/YR

NUS CORPORATION

DATE 3/25/81

CLIENT FESA FILE NO. 5398-M-04 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. Lelko

2. CEILING AREA AND INSULATION COST

THE CEILING AREA = 37,764 FT^2, FROM DRAWINGS

THE INSTALLED COST FOR BLOWING IN APPROXIMATELY 2" OF INSULATION IS APPROXIMATELY \$.50/FT^2

∴ THE ESTIMATED INSTALLED COST FOR ADDING 2" OF BLOWN INSULATION IS

Cost = 37764 FT^2 x \$.50 = \$19,000

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade, Kimborough Army Hospital FY 1981

Project: Adding 2" insulation to the roof of old hospital

Economic Life 25 Yrs. Date Prepared 3/25/81 Prepared by G. A. Lelko

COSTS

1.	Non-Recurring Initial Capital Costs:	
	a. CWE	$ 19,000
	b. Design	$ 0
	c.	$ 0
	d. Total	$ 19,000

BENEFITS

2.	Recurring Benefit/Cost Differential Other than Energy:	
	a. Annual Labor Decrease (+)/Increase (-)	$ 0
	b. Annual Material Decrease (+)/Increase (-)	$ 0
	c. Other Annual Decrease (+)/Increase (-)	$ 0
	d. Total Costs	$ 0
	e. 10% Discount Factor	$ 0
	f. Discounted Recurring Cost (d x e)	$ 0
3.	Recurring Energy Benefit/Costs:	
	a. Type of Fuel: Oil	
	(1) Annual Energy Decrease (+)/Increase (-)	+ 370 MBTU
	(2) Cost per MBTU	$ 11.19
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 4,140
	(4) Differential Escalation Rate (8 %) Factor	20.050
	(5) Discounted Dollar Decrease/Increase (3)x(4)	$ 83,007
	b. Type of Fuel: Electricity	
	(1) Annual Energy Decrease (+)/Increase (-)	+ 271*KWH
	(2) Cost per KWH	$ .04
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$ 10.84
	(4) Differential Escalation Rate (7 %) Factor	18.049
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ 195.65
	c. Type of Fuel:	
	(1) Annual Energy Decrease (+)/Increase (-)	
	(2) Cost per MBTU	$
	(3) Annual Dollar Decrease/Increase ((1)x(2))	$
	(4) Differential Escalation Rate (___%) Factor	
	(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
	d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 83,202
4.	Total Benefits (Sum 2f+3d)	$ 83,202
5.	Discounted Benefit/Cost Ratio (Line 4/Line 1d)	4.38
6.	Total Annual Energy Savings (3a(1)+3b(1)+3c(1))	373 MBTU
7.	E/C Ratio (Line 6 ÷ Line 1a/1000)	19.6
8.	Annual $ Savings (2d+3a(3)+3b(3)+3c(3))	$ 4,150
9.	Pay-Back Period ((Line 1a - Salvage)÷Line 8)	4.6 Years

*3.14 MBTU at generating station

CLIENT FESA	CALC. No. 5398-M-05
SUBJECT Condensate Return Leak in New Addition	

PROBLEM:

Estimate energy loss and cost for condensate return leakage in new clinic

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

See attached sheet

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

See attached sheet

CHECKER'S REMARKS:

CONCLUSIONS:

Energy loss	≈	9.6 MBTU/Season
Water loss	≈	9600 Gal/Season
Cost for fuel	≈	$105.60/Season
Cost for makeup water	≈	$28.80/Season

CHECKER'S REMARKS:

CALCULATED BY	DATE
R. W. Fell	3/25/81
CHECKED BY	DATE
G. A. Lelko	7/8/81

ED-501 (2/80)

NUS CORPORATION

DATE 3/25/81

CLIENT FESA FILE NO: 5398-M-05 BY R.W. FELL

SUBJECT KIMBOROUGH Hospital ENERGY AUDIT Checked By G.A. LELKO

PROBLEM: Evaluate THE EFFECT of REPAIRING the CONDENSATE leak in the NEW ADDITION

SOLUTION:

① Estimated quantity of water Lost

LEAK RATE ≈ 4 gallon/HR (BY ON-SITE ESTIMATE)

HEAT Lost per SEASON

$$Q = M C_p \Delta T$$

$$Q_{condensate} = 4\ gal/HR \times 8.3\ LB/gal \times 24\ \frac{hr}{day} \times 100\ DAY/SEASON \times (180-60)F \times 1\ \frac{BTU}{LB-F}$$

where (180 − 60) = STEAM TEMPERATURE MINUS MAKEUP WATER TEMPERATURE

$$Q_{condensate} = 9.56 \times 10^6\ BTU/SEASON$$

$$\text{Fuel Cost} = 9.56 \times 10^6\ BTU/SEASON \times \$11/10^6\ BTU = \$105.60/SEASON$$

② QUANTITY of MAKEUP WATER

$$4\ gal/HR \times 24\ hr/DAY \times 100\ DAY/SEASON = 9600\ gal/SEASON$$

Cost for makeup water (@ $3/1000 gal)

$$= 9600\ gal \times \$3/1000\ gal = \$28.80/SEASON$$

CLIENT	CALC. No.
FESA	5398-M-06

SUBJECT
Steam Leakage at Kimborough Army Hospital

PROBLEM:

Evaluate the energy loss associated with observed steam leakage in the hot water heating system.

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

See attached sheet

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

See attached sheet

CHECKER'S REMARKS:

CONCLUSIONS:

Energy loss $\approx$ 43.8 MBTU/Yr
Makeup water $\approx$ 5290 Gal/Yr
Energy cost $\approx$ \$481/Yr

CHECKER'S REMARKS:

CALCULATED BY	DATE
R. W. Fell	3/25/81
CHECKED BY G. A. Lelko	DATE 7/8/81

ED-501 (2/80)

NUS CORPORATION

Page 1 of 1
DATE 3/25/81

CLIENT FESA FILE NO. 5398-M-06 BY R.W. FELL
SUBJECT KIMBOROUGH Hospital Energy Audit Checked By G.A. LELKO

PROBLEM: EVALUATE THE Effect of observed STEAM LEAKAGE FROM THE HOT WATER HEATING SYSTEM IN THE HOSPITAL BASEMENT.

ESTIMATED LEAKAGE = 5 LB/HR (BY OBSERVATION)

① HEAT LOST = $5\ LB/HR \times 1000\ \frac{BTU}{LB} \times 8760\ HR/YR$

$= 43.8 \times 10^6\ BTU/YR$

Cost of HEAT LOST = $43.8 \times 10^6\ BTU/YR \times \$11/10^6 BTU$

$= \$481/YR$

② MAKEUP WATER = $5\ LB/HR \times 8760\ HR/YR \times \frac{1\ GAL}{8.3\ LB} =$

$= 5290\ GAL/YR$

Cost of MAKEUP WATER (@ \$3/1000 GAL)

$= 5290\ GAL \times \$3/1000\ GAL$

$\approx \$16/YEAR$

CLIENT	CALC. No.
FESA	5398-M-07
SUBJECT: Add 4" Insulation to Drop Ceiling of New Clinic	

PROBLEM:

Evaluate adding 4" of insulation to the top of the drop ceiling beneath the roof of the new clinic section of the Kimborough Army Hospital

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

DOE-2 computer runs were made to simulate the performance of the hospital before and after the insulation was added

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

Area of the roof is approximately 56,000 Ft^2 based on review of drawings

CHECKER'S REMARKS:

CONCLUSIONS:

Total energy saved $\approx$ 579 MBTU
E/C ratio $\approx$ 20.7
Simple payback period $\approx$ 4.6 Years

CHECKER'S REMARKS:

CALCULATED BY	DATE
R. W. Bell	3/7/81
CHECKED BY	DATE
G. A. Lelko	7/8/81

ED-501 (2/80)

NUS CORPORATION

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-07 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. LELKO

PROBLEM: EVALUATE THE ADDITION of INSULATION TO THE SPACE ABOVE THE DROP CEILING IN THE NEW CLINIC

SOLUTION:

HEATING AND COOLING DEMANDS: FROM THE RESULTS OF DOE-II COMPUTER RUNS, the following HEATING AND COOLING CHARACTERISTICS ARE PREDICTED:

	Present (mBTU/yr)	After Addition of 4" insulation (mBTU/yr)	Energy Savings (mBTU/yr)
HEATING	2680	2147	~ 540
Cooling	1479	1432	~ 47

Cost Savings for heating = 540 mBTU/YR × \$11/mBTU = \$5940

Cooling electricity saved = $\frac{47 \times 10^6 \text{ BTU}}{4} \times \frac{1 \text{ Kwhr}}{3412 \text{ BTU}} = 3443 \frac{\text{Kwhr}}{\text{YR}}$

where 4 = C.O.P. of CHILLER

Cost savings for electricity = 3443 Kwhr × \$.04/Kwhr = \$138

Energy Saved at the electric power generation station =

$3443 \text{ kwhr/yr} \times 11600 \text{ BTU/kwhr} = 39 \times 10^6 \text{ BTU/yr}$

where

11,600 BTU/kwhr = assumed HEAT RATE of generating station

NUS CORPORATION

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-07 BY R.W. FELL

SUBJECT Kimborough Hospital Energy Audit Checked By G.A. LELKO

ESTIMATED COST FOR INSTALLING BLOWN INSULATION IN DROP CEILING IN NEW ADDITION.

Area of drop ceiling $\approx$ 56,000 FT^2

The estimated cost for installing blown insulation is \$.50/FT^2. Therefore the installed cost for the insulation is estimated to be:

$$\text{Cost} = 56{,}000\ FT^2 \times \$.50/FT^2 = \$28{,}000$$

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade Army Hospital FY 1981

Project: Add 4" insulation to drop ceiling of new clinic

Economic Life 25 Yrs. Date Prepared 3/7/81 Prepared by R.W. Fell

COSTS

1. Non-Recurring Initial Capital Costs:
   - a. CWE $ 28,000
   - b. Design $ 0
   - c. ______ $ 0
   - d. Total $ 28,000

BENEFITS

2. Recurring Benefit/Cost Differential Other than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ 0
   - b. Annual Material Decrease (+)/Increase (-) $ 0
   - c. Other Annual Decrease (+)/Increase (-) $ 0
   - d. Total Costs $ 0
   - e. 10% Discount Factor $ 0
   - f. Discounted Recurring Cost (d x e) $ 0
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Oil Heating
     - (1) Annual Energy Decrease (+)/Increase (-) 540 MBTU
     - (2) Cost per MBTU $ 11 MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 5,940
     - (4) Differential Escalation Rate (8 %) Factor 20.050
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ 119,100
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 3,443 KWHR*
     - (2) Cost per MBTU $ .04
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 138
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 2,490
   - c. Type of Fuel: -
     - (1) Annual Energy Decrease (+)/Increase (-) ______
     - (2) Cost per MBTU $ ______
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______
     - (4) Differential Escalation Rate (- %) Factor ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   - d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 121,590
4. Total Benefits (Sum 2f+3d) $ 121,590
5. Discounted Benefit/Cost Ratio (Line 4/Line 1d) 4.3
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)) 579 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 20.7
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)) $ 6,078
9. Pay-Back Period ((Line 1a - Salvage)÷Line 8) 4.6 Years

*39 MBTU at generating station

CLIENT	CALC. No.
FESA	5398-M-08

SUBJECT Install 2" of Insulation with Fan Cycling for New Addition of Kimborough Army Hospital

PROBLEM:

Evaluate the merits of adding 2" of insulation to the roof of the new addition if it already has installed the fan cycling control scheme

CHECKER'S REMARKS:

APPROACH/ASSUMPTIONS:

DOE-2 computer runs were made to simulate the performance of the new addition with fan cycling before and after 2 inches of insulation was added

CHECKER'S REMARKS:

SOURCES-DATA/EQUATIONS:

Area of roof for new addition is approximately 56,000 Ft^2 based on review of drawings.

CHECKER'S REMARKS:

CONCLUSIONS:

Total energy saved	=	211 MBTU
Simple payback period	=	6.6 Years
E/C ratio	=	12.5

CHECKER'S REMARKS:

CALCULATED BY	DATE
R. W. Fell	3/7/81
CHECKED BY	**DATE**
G. A. Lelko	7/8/81

ED-501 (2/80)

CLIENT FESA FILE NO. 5398-M-08 BY R.W. FELL

SUBJECT Kimbrough Hospital Energy Audit Checked By GA LELKO

PROBLEM: EVALUATE THE EFFECT OF ADDING 2" ADDITIONAL INSULATION TO THE ROOF OF THE NEW CLINIC IF THE FAN CYCLING SYSTEM SUGGESTED IN PROJECT No. 1 IS EMPLOYED.

SOLUTION: THE FOLLOWING HEATING AND COOLING DEMANDS FOR THE NEW ADDITION WERE PREDICTED BY THE DOE-II COMPUTER CODE.

	FAN CYCLING ONLY (M BTU/YR)	FAN CYCLING W/ 2" INSULATION (M BTU/YR)	ENERGY SAVINGS (MBTU/YR)
HEATING	1111	872	239
COOLING	922	955	-33

ADDITIONAL ELECTRICITY CONSUMED =

$$\frac{-33 \times 10^6 \text{ BTU/YR}}{4} \times \frac{1 \text{ Kwhe}}{3412 \text{ BTU}} = -2420 \text{ Kwhe/YR}$$

ADDITIONAL FUEL CONSUMED AT GENERATING STATION

2420 KWHR × 11600 BTU/KWHR = 28 MBTU/YR

TOTAL ENERGY SAVED = 239 MBTU/YR − 28 MBTU/YR = 211 MBTU/YR

NUS CORPORATION

DATE 3/7/81

CLIENT FESA FILE NO. 5398-M-08 BY RW FELL

SUBJECT Kimborough Hospital Energy Audit Checked By GA LELKO

THE INSTALLED COST FOR BLOWING 2" INSULATION INTO THE CEILING AREA IS ESTIMATED AS FOLLOWS:

AREA OF CEILING: 56000 FT^2

ESTIMATED COST PER SQUARE FOOT IS \$.30/FT^2 Therefore THE TOTAL ESTIMATED INSTALLED COST IS:

$$\text{Cost} = 56{,}000\ FT^2 \times \$.30/FT^2 = \$16{,}800$$

ECONOMIC ANALYSIS SUMMARY

Location: Ft. Meade Army Hospital FY 1981

Project: Install 2" of insulation with fan cycling for the new addition clinic

Economic Life 25 Yrs. Date Prepared 3/7/81 Prepared by R. N. Fell

COSTS

1. Non-Recurring Initial Capital Costs:
   - a. CWE $ 16,800
   - b. Design $ 0
   - c. ______ $ 0
   - d. Total $ 16,800

BENEFITS

2. Recurring Benefit/Cost Differential Other than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ 0
   - b. Annual Material Decrease (+)/Increase (-) $ 0
   - c. Other Annual Decrease (+)/Increase (-) $ 0
   - d. Total Costs $ 0
   - e. 10% Discount Factor $ 0
   - f. Discounted Recurring Cost (d x e) $ 0

3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Heating Oil
     - (1) Annual Energy Decrease (+)/Increase (-) 239 MBTU/Yr
     - (2) Cost per MBTU $ 11
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 2,629
     - (4) Differential Escalation Rate (8 %) Factor 20.05
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ 52,711
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) - 2,420 KWHR*
     - (2) Cost per MBTU $ .04
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ - 100
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ - 1,804
   - c. Type of Fuel: -
     - (1) Annual Energy Decrease (+)/Increase (-) ______
     - (2) Cost per MBTU $ ______
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______
     - (4) Differential Escalation Ra... (- %) Factor ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   - d. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 50,907

4. Total Benefits (Sum 2f+3d) $ 50,907
5. Discounted Benefit/Cost Ratio (Line 4/Line 1d) 3.03
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)) 211 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 12.5
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)) $ 2,529
9. Pay-Back Period ((Line 1a - Salvage)÷Line 8) 6.6 Years

*28 MBTU at generating station

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